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Mountain Pine Beetle Infestation And Armillaria Root Disease Of Ponderosa Pine

In The Black Hills Of South Dakota

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MOUNTAIN PINE BEETLE INFESTATION AND ARMILLARIA ROOT DISEASE OF PONDEROSA PINE IN THE BLACK HILLS OF SOUTH DAKOTA

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ABSTRACT

A total of 115 trees were examined on 40 plots located throughout the northern Black Hills National Forest. A significant association ($P = 0.05$) was found between *Armillaria mellea* root disease and ponderosa pine tree mortality attributed to mountain pine beetle infestation. Seventy-five percent of the dead trees, 28% of the currently beetle-infested trees, but none of the live trees had *A. mellea* root infection. All trees had good crown ratios and were equally distributed between single- and two-storied stands of moderate basal area on good quality sites.

INTRODUCTION

The mountain pine beetle (*Dendroctonus ponderosae* Hopk.) is the major cause of ponderosa pine (*Pinus ponderosa* Dougl.) mortality in the Black Hills of South Dakota (Fig. 1). Approximately 350,000 trees were killed by the beetle on an estimated 300,000 acres in the Black Hills in 1980 (Raimo and Sharon 1980). Near endemic beetle conditions occurred in 1982 over most of the Black Hills. This condition marked the end of an 11-year infestation cycle that claimed an estimated 4.2 million ponderosa pines (from aerial survey records, Timber, Forest Pest amd Cooperative Forestry Management Staff Unit, USDA Forest Service, Rocky Mountain Region).

Mountain pine beetle outbreaks in ponderosa pine seldom develop suddenly (Sartwell and Stevens 1975). Scattered, small groups of trees are attacked first. Neighboring trees are then killed, enlarging the infested area over a period of several or more years. Various tree and stand conditions are associated with beetle outbreaks of ponderosa pine (Beal 1943, Keen 1936, Sartwell and Stevens 1975), including the association between bark beetle attacks and root disease, *Armillaria mellea* (Vahl.:Fr.) Quel. (Cobb et al. 1974, Fuller 1983, Livingston et al. 1983, Partridge and Miller 1972). The object of this study was to investigate the association between the presence of root diseases, bark beetle infestation, and ponderosa pine mortality on the two major soil types in the Black Hills of South Dakota.

METHODS

Twenty temporary plots were established in pure pine stands in each of the major timber producing crystalline and limestone areas (Bolt and Van Deusen 1974) in the northern portion of the Black Hills National Forest in October 1982 (Fig. 2). Each plot, usually less than 0.5 acre, was selected so that it contained: 1 to 3 recently dead, beetle-attacked pines killed within 1 or 2 years; a live uninfested tree of similar size; and a currently beetle-infested live tree when possible. Because of the low level of beetle infestation, it was necessary to examine numerous stands to determine their suitability for plot establishment. Information was recorded on stand structure (single-, two-, or multi-storied), basal area, and site index based on age and height of at least three dominant or co-dominant trees for each plot. The presence or absence of reproduction on a plot was not considered in plot selection, nor was the physical condition of the regeneration noted until after tree measurements were taken. Tree data recorded included tree height, size, age at breast height, tree crown classification, and obvious major defects such as dead top, fire scar, etc. Beetle infestation included the identity of the primary insect and the presence of root insects.

One dead tree, one nearest uninfested live, and one currently infested sample tree (if present) were felled on each plot. Stumps were cut close to the ground to facilitate examination for evidence of internal defects,

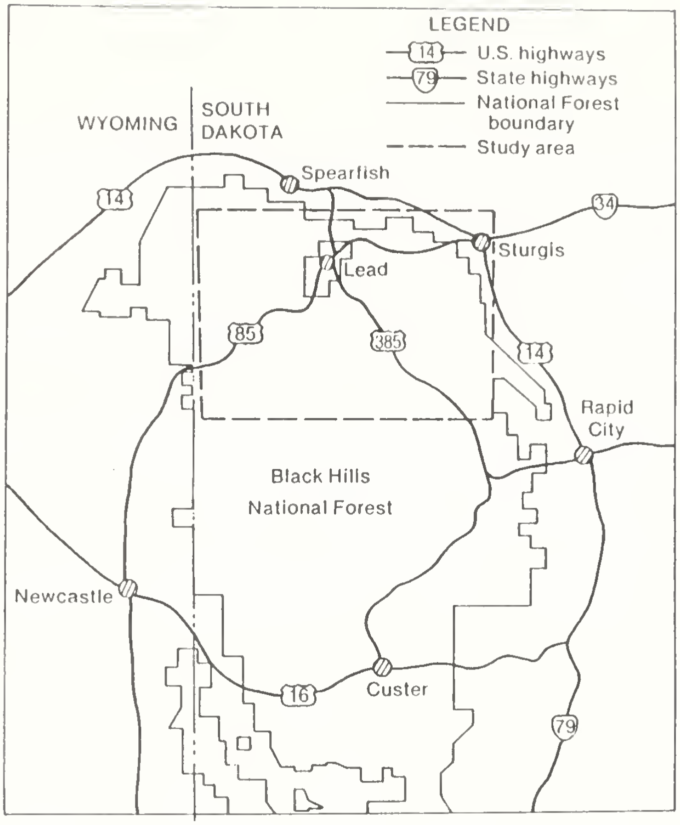

Figure 1. Vicinity map of the Black Hills National Forest, South Dakota.

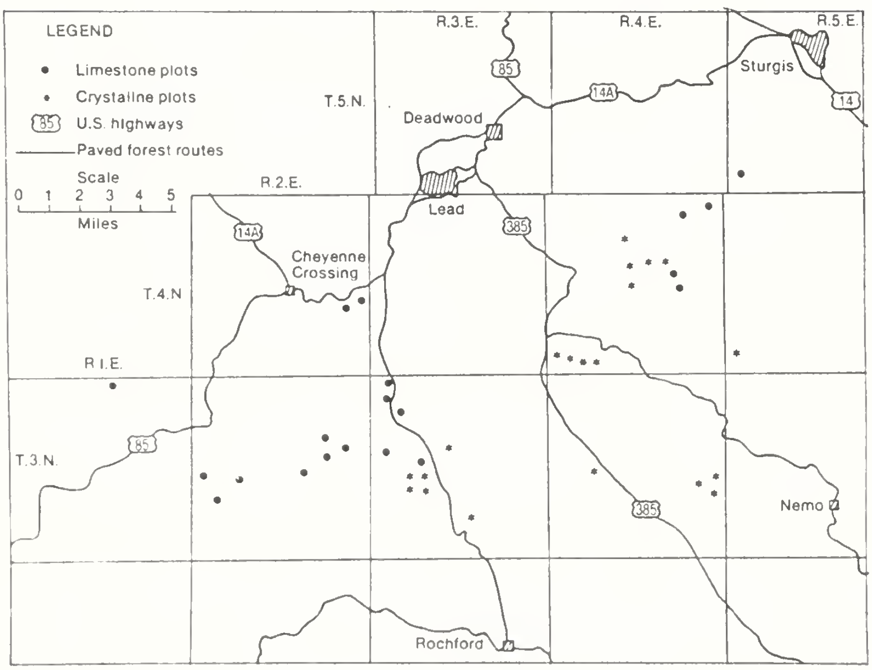

Figure 2. Mountain pine beetle infestation and Armillaria root disease study area in the Black Hills National Forest.

i.e., fire scars, butt rot, stain, and root rot. The root collar was examined for evidence of resinosis and white mycelial fans of *A. mellea*. When fans were not present, 1 to 3 major roots were excavated for a distance of 3 feet and examined for evidence of subcortical mycelial fans and rhizomorphs, indicative of root infestion. Roots were severed to ascertain possible internal infection, stain, and condition. When there was more than one dead tree on a plot, the additional dead trees were examined only for root collar and root infection.

A total of 115 trees were examined on the 40 plots; however, only 40 dead trees, 40 uninfested, and 11 sustaining a current beetle attack were cut for sample trees. In addition, 17 dead and 7 currently beetle-attacked trees were observed on the plots. Contingency tables were used to analyze the association between tree mortality, mountain pine beetle attack, and *A. mellea* root infection. The t-test was used for other plot and tree attributes. Results were tested for significance at the 95% confidence level (P = 0.05).

RESULTS

Of the 57 dead trees examined, 52 were considered beetle attacked and killed in 1981, 4 in 1980, and 1 in 1979. There was no evidence of *A. mellea* on one tree killed in 1979 and two killed in 1980. With the exception of one live tree with a single, small, confined root wound infected with *A. mellea*, the fungus was not found on the live trees. Because the wound was callusing, the infection was considered to be quiescent. The basic plot data for all trees are given in Table 1.

The association between dead trees infested with the mountain pine beetle and the presence of *A. mellea*-infested roots in the sample trees cut on the 40 plots (Table 2) was significant (P = 0.05). Of 19 plots with only 1 dead tree--9 on the limestone and 10 on the crystalline areas--root infection was associated with beetle-killed trees 89% and 90% of the time, respectively. Of the 57 beetle-killed trees, 75% had root infection. Analysis of the combined data indicated a significant association between primary insect attack and single trees with advanced root infection.

Without intensive investigation to estimate the distribution of *A. mellea* in the sampled stands, a definitive test of whether beetles are selectively attacking the currently infested trees could not be made. There were 11 plots, 5 on the limestone and 6 on the crystalline areas, with 18 currently attacked trees. The incidence of *A. mellea* infection was 28%.

No association between stand structure and root infection was evident. Eighty percent of the sample trees in both of the single- and two-story stands were infected. The mean stem basal area of the 40 plots was 115 $\pm$ 45 ft^2 and although the basal area was slightly higher on the crystalline area, the difference was not significant.

Table 1. Number of dead trees with beetles, current beetle-attacked, and healthy trees; and incidence of *A. mellea* root infection on 40 plots.

Area	Trees cut						Trees observed			
	Number of trees			Root infected (%)			Number of trees		Root infected (%)	
	Dead	Current attack	Live	Dead	Current attack	Live	Dead	Current attack	Dead	Current attack
Limestone	20	5	20	85	60	0	9	4	78	25
Crystalline	20	6	20	75	17	0	8	3	50	0
Total	40	11	40	80	36	0	17	7	65	14

Table 2. Contingency table for comparing sample trees on 40 plots with the presence of bark beetles and *A. mellea*-infected roots.

	A. mellea (no.)	No *A. mellea* (no.)	Total (no.)
Dead, with beetles	32	8	40
Healthy, with no beetles	0	40	40
Total	32	48	80

Sample tree age at 4.5 feet ranged from 49 to 119 years. The mean tree age was 81 $\pm$ 19 years on the limestone area, and 75 $\pm$ 19 on the crystalline area. Site index in the Black Hills ranges from 40 to 80 feet at base age of 100 years (Bolt and Van Deusen 1974). Sample plot site indices varied from 60 to 80. There were no significant site differences between the two areas. The mean site index for all 40 plots was 76 $\pm$ 6, indicating the sample plots were located on the better sites. Sample plots were located on slopes from level to 60%. The mean slope was greater for the limestone plots (20 $\pm$ 15%) than on the crystalline plots (11 $\pm$ 13%). Although the few dead trees without root infection were found on the lesser slopes, real differences in slope steepness and root infection could not be determined from this limited study.

There was no significant difference between the average size of dead and live trees on each soil type; there was a difference between the two areas. The mean tree diameter at breast height on the limestone was 10.9 $\pm$ 2.6 inches, and on the crystalline area 13.4 $\pm$ 3.0 inches. The predominant tree crown class initially attacked was co-dominant (71%), followed by intermediate (18%) and dominant (11%). Live crown ratios of live and dead trees, respectively, on the limestone areas was 54 $\pm$ 12% and 48 $\pm$ 11%; on the crystalline area, 53 $\pm$ 7% and 49 $\pm$ 9%.

Tree defects such as frost cracks, logging scars, spike tops, dead leaders, fire and lightning scars, and butt rot, which could cause loss of tree vigor, were found on some of the dead, currently attacked, and healthy trees. Most scars were healed over with little or no associated decay, and all defects were considered noncontributory to loss of tree vigor which might predispose a tree to insect attack. Blue stain fungi were found in the roots of 3 dead trees. A pronounced red-streaked stain of the sapwood and heartwood was present on the stump in 79% of the dead trees and 36% of the attacked trees. This red-stained wood has previously been reported in beetle-killed ponderosa pine in Colorado (Davidson 1979). *Armillaria mellea* root rot was present on the stump of 5 dead and 1 currently attacked trees, indicating an advanced root and butt rot infection. Although not all the roots of the trees were examined, *A. mellea*-infected roots were found in about equal numbers in the four cardinal directions and slope positions. One unidentified decay fungus was found in the roots of 3 dead trees.

The red turpentine beetle (*Dendroctonus valens* Lec.), which attacks the base of injured, dying, or healthy trees, was found on 19% of the dead trees, but on only one currently attacked tree. Other secondary bark beetles belonging to the genus *Hylastes* were present on the roots of 35% of the dead trees, but not on any of the currently attacked or healthy trees.

Evidence of past logging was noted on 90% of the limestone and 70% of the crystalline plots. Ponderosa pine regeneration was present on 80% of the limestone and 65% of the crystalline plots. Visible presence of *A. mellea* i.e., dead trees with a girdled root collar, was found on 30% of the limestone and 8% of the crystalline plots with pine regeneration.

DISCUSSION

Killing by beetles of three of more adjacent trees in a single season is usually considered to be the lower limit of a beetle outbreak (Sartwell and Stevens 1975). The inception of a successful initial attack is often obscure, since many initial attacks are successful and the tree survives. Nearly half of the plots in this study contained only one dead tree, and these successful attacks were found to have a significant association with root infection by *A. mellea*. Overall, there were 1.4 dead trees per plot, indicating the study plots sustained initial beetle attack and mortality below the lower limit considered a beetle outbreak.

None of the dead, currently attacked, or healthy trees contained internal or external defects above ground that could be considered deleterious to tree health. How rapidly *A. mellea* is capable of colonizing roots after a tree has been killed is unknown. Many dead trees had more than one infected root with mycelial fans of the fungus extending above the root collar beneath the bark, indicating an extensive stage of root infection.

A majority of the killed and attacked trees were dominants and co-dominants with good live crown ratios. These trees were equally distributed between single- and two-storied stands of moderate basal area on good quality sites in both basic soil types. We speculate that a bark beetle outbreak can be initiated by the interating roles played by the beetle and *A. mellea* root disease. Once the disease has reached or girdled the root collar, the prognosis for tree survival is poor and, when attacked by beetles, tree mortality is rapid. The beetles may then emerge the following year and infest nearby trees, which may or may not be weakened by root infection; or the beetles may migrate to another, more vulnerable, ponderosa pine stand. What perpetuates the infestation is beyond the scope of this study.

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